CUSTOM COLOR PRINTING APPARATUS AND PROCESS

CROSS-REFERENCE TO RELATED APPLICATIONS

(001) This application claims the benefit of United States Provisional Patent Application serial number 60/458,789 filed March 28, 2003.

BACKGROUND

(002) The invention relates to the use of custom color inks in printing.

(003) In printing, custom colors are often used for accent colors. For use with printing presses, custom color inks are pre-mixed and are typically used for large runs with long setup times for each job. Such pre-mixing of large batches is inefficient for smaller print jobs that make use of custom colors, and setup and cleanup can be difficult and time consuming.

SUMMARY

(004) According to various aspects of the invention, printing apparatus and processes are provided for dispensing a first primary color ink to a custom color chamber associated with a print head; dispensing a second primary color ink to the custom color chamber; mixing the first primary color ink and the second primary color ink to create a custom color; and printing the custom color ink from the custom color chamber with a print head. A related aspect of the invention is an arrangement of valves for selecting a printing ink from a number of available ink chambers, and feeding the selected ink to a print head.

BRIEF DESCRIPTION OF THE DRAWINGS

(005) Fig. 1 is a schematic block diagram of a custom-color print apparatus.

(006) Fig. 2 is a schematic diagram of a custom-color print apparatus including a controller.

(007) Figs. 3a and 3b are plan views of a valve used in the custom-color print apparatus of Figs. 1-2.

(008) Fig. 4 is a partial schematic view of a custom-color print apparatus employing the valves of Figs. 3a and 3b.

DETAILED DESCRIPTION

(009) As illustrated in Fig. 1, a custom color print apparatus 10 is provided for feeding custom ink colors to a print head 12 for printing custom accent colors, for example. The print head 12 may be, for example, an inkjet print head. The custom color print apparatus is provided with a number of primary color chambers 14a, 14b, and 14n for storing primary color ink (first primary color chamber, second primary color chamber, third primary color chamber,. . . n primary color chambers, where n is an integer number greater than 2). The number of primary color chambers is preferably at least two, but it may be any number as determined by appropriateness for any particular application. The primary color ink may include ink in the colors of cyan, magenta, yellow, black, and white. The term primary color ink as used herein is not limited to a "primary color" as defined under color theory. Rather, the term primary color ink is used herein to include any color of ink that may be mixed with another ink to form a custom color of ink.

(010) Dispensing pumps 16a, 16b, 16n are provided to dispense a predetermined quantity (for example metered quantities) of the primary color ink to one or more custom color chambers 20a, 20b, 20n (first custom color chamber, second custom color chamber, third custom color chamber, . . . n custom color chambers, where n is an integer number greater than 1). As illustrated in Fig. 1, each custom color chamber is fitted with supply lines from each primary color. The custom color chambers need not be limited to separate containers but may be, for example a region of tubing in which inks are capable of blending.

(011) Custom color selectors such as valves 18a, 18b, 18n may be provided to control the flow of primary color ink into the custom color chambers to ensure that primary color ink pumped by the dispensing pumps is directed into a selected one of the custom color chambers 20a, 20b, 20n. One or more of the valves 18a, 18b, 18n may comprise a dispensing valve operative to dispense a predetermined quantity (for example metered quantities) of ink into the custom color chamber, for example a low-resolution, low speed inkjet nozzle such as a Lee Valve (VHS-Lt Direct Dispensing Micro-Drop Valve, The Lee Company, Westbrook, CT), which can be used to put drops of primary color ink in the custom color chambers 20a, 20b, 20n. One such valve may be provided for each line leading from the primary color chambers to the secondary color chambers (e.g., an individual valve 18a, and/or 18b, . . . and/or 18n, may include two, three, or more Lee Valves, one for each of the primary color chambers 14a, 14b, and 14n).

(012) Although three custom color chambers and three primary color chambers are illustrated in Fig. 1, the number of primary color chambers and custom color chambers need not be the same. In one embodiment, five primary color chambers might be used in conjunction with a single custom color chamber.

(013) The custom color chambers 20a, 20b, 20n may be provided with one or more mixers (not illustrated), which may be, for example, mechanical, magnetic, pneumatic, hydraulic, or ultrasonic stirrers, powered by electricity or other suitable source. The custom color chambers may be removable for storage outside the color print apparatus, and/or to enable swapping of custom colors. Moreover, the custom color chambers may be disposable to simplify cleanup when a new custom color is desired. Preferably, where a previously-mixed color is obtained (such as a color mixed outside of the print apparatus), a chamber containing that color can be added to the print apparatus.

(014) The custom color chambers 20a, 20b, 20n are associated with the print head 12. When printing is performed using custom colors, one or more feed

pumps 22a, 22b, 22n feed custom color ink from the custom color chambers 20a, 20b, 20n through feed valves 24a, 24b, 24n to the print head 12.

(015) A source of purging fluid is provided, such as a reservoir 21 with a pump 23 to pump the purging fluid through the portions of the color print apparatus such as the feed valves 24a, 24b, 24n and the print head 12. The purging fluid pump is operative to direct purging fluid from the purging fluid reservoir 21 to the feed valves 24a, 24b, 24n. The feed valves are operative to alternatively direct purging fluid from the purging fluid pump 23 or ink from a corresponding custom color chamber 20a, 20b, 20n to the print head 12. The purging fluid is used to clear one color of ink from the print apparatus when it is desired to switch to another color of ink, thereby preventing different ink colors from mixing unintentionally. The print apparatus can be purged by printing ink to a waste receptacle or to the receiver. The feed valves 24a, 24b, and 24n may be provided with bleed lines (illustrated in groups of three) 26a, 26b, and 26n to release purging fluid and/or excess ink from the apparatus.

(016) The pumps in the apparatus may be systolic pumps. The term "pump," as used herein is broadly used to encompass various arrangements for propelling liquid, such as an arrangement for providing a pressure gradient or a gravity-feed arrangement.

(017) A schematic illustration of the print apparatus is provided in Fig. 2. Primary color chambers 14a and 14b are shown, together with dispensing pumps 16a and 16b, both of which feed to the valve 18a leading to the custom color chamber 20a. A feed tube 56 passes from the custom color chamber 20a through a wiper 58 to the feed pump 22a. The feed pump 22a draws the custom color through the feed tube 56 and provides it, through the valve 24a, to the print head 12. Additional components of the print apparatus, such as additional primary and/or custom color chambers and associated valves, are not illustrated in Fig. 2 for simplicity.

(018) The print apparatus is preferably operated under the control of a controller 50, which may include a central processing unit (CPU), such as the CPU of a general-purpose computer programmed by software to operate the print apparatus, or a special-purpose computer or logic circuit designed to operate the print apparatus. The controller may accept an input indicating one or more custom colors to be used by the print apparatus. The input may accept a color identification through, for example, RGB value or Pantone number, or the input may include an optical scanner that reads a color sample to create a match, or the input may receive a formula that identifies proportions for mixing primary color inks to form a custom color. As the print head 12 prints on a receiver 52, such as a sheet of paper, a print color sensor 54 may detect the color printed by the print head 12. This sensing may be used to verify the changing of the color of ink printed by the print head 12, and the constancy of the ink color during print jobs. An ink color sensor 86 may be positioned to sense a color of ink in the custom color chamber. The sensors 52 and 86 may be optical sensors, for example, or any sensor suitable for sensing a print or ink color, respectively.

(019) Based on the readings from the print sensor 54 and/or the ink sensor 86, the controller 50 may make corrections to the custom colors. The print apparatus may, for example, print one or more proofs monitored by the sensor 54, with the controller 50 controlling a cycle that may include adjusting the custom color ink, purging, and printing until the detected color on the page matches a desired custom color. The print sensor 54 may also be used to measure the color of the custom color portions of the image during print jobs. If this custom color varies from the specified color, it can be corrected during the print job by the controller 50 The controller 50 may be operative to induce dispensing of ink from one or more of the primary color chambers 14a, 14b, 14n into the custom color chamber 20a, 20b, 20n in order to match a color printed by the print head 12 to a predetermined print color with feedback from the print sensor 54. In similar manner, the controller 50 may be operative to induce dispensing of ink from one or more of the primary color chambers 14a, 14b, 14n into the custom color chamber 20a, 20b, 20n in order to match the color of ink in the custom color

chamber 20a, 20b, 20n to a predetermined custom color of ink with feedback from the ink sensor 86. The controller 50 may be operative to report the color of ink in the custom color chamber 20a, 20b, 20n, and/or the color printed by the print head 50, to a print apparatus operator.

(020) The print sensor 54 may be implemented to verify the changing of the color of ink printed by the print head. A change of the custom color to another custom color may be verified by printing the purging fluid and/or the another custom color on at least one receiver with the print head 50. The printing process may comprise directing the at least one receiver to a different destination than a bulk of receivers printed with the custom color, for example for proofing, or to a waste receptacle. The apparatus operator may verify the color change, or the controller 50 may be operative to verify the color change with feedback from the print sensor 54.

(021) The primary color chambers 14a, 14b, 14n, color chambers 20a, 20b, 20n, and the purging fluid reservoir 21 may be provided with low-level sensors (not shown) to indicate when fluid levels are low. The controller 50 may be operative to halt printing by the print head 12 in response to the at least one low level sensor sensing a low fluid level and to notify a print apparatus operator.

(022) Multiple sets of the custom color printing apparatus 10, each with at least one print head, may be included in a printing machine to print color separations sequentially in register on the receiver. These separations may contain primaries C,M,Y,K, custom colors, or other color sets, such as for duotones.

(023) The valves of the apparatus are selected so that they do not retain fluid and are easily purged. They can be controlled by, for example, stepper motors or solenoids operated by the controller. One type of valve that is well adapted for use in the print apparatus as a feed valve, such as one or more of the valves 24a, 24b, and 24n, is illustrated in Figs. 3a and 3b. The valve 24a includes external ports 70, 72, 74, 76, 78, 80, 82, and 84. The valve 24a also includes internal ports 73, 75, 79, and 83. The rotary portion of the valve contains straight

passages 71 and 81. In the view shown in Figs. 3a and 3b, passage 71 and 81 are at different levels, and passage 71 crosses over passage 81. Correspondingly, passage 71 is shown with heavily dashed lines. and passage 81 is shown with lines having alternating dashed and dotted sections. The level of the other passages in the valve is indicated by like-dotted lines. For example, the passage from external port 74 to external port 84 is at the level of passage 81. The openings of internal ports 73, 75, 79, and 83 are enlarged to connect to openings in the rotary portion of the valve at either the level of passage 71 or the level of passage 81.

(024) Fig. 3a illustrates the feed valve 24a in the bleed/prime position. The ports 72 and 74 are coupled to the purging fluid pump 23, the ports 76, 78, and 80 are coupled to the bleed lines 26a (see Fig. 1), and the ports 82 and 84 are coupled to the next feed valve 24b. In the bleed/purge position of Fig. 3a, the ports 70, 74, and 84 are all coupled to the bleed lines, while the port 72 flows to the port 82.

(025) Fig. 3b illustrates the valve 24a in the feed position. In the feed position, the ports 72, 74, and 84 are coupled to the bleed lines, while the port 70 flows to the port 82. When the valve 24a is in either the feed position or in the bleed/prime position, a portion of the purging fluid fed into the port 74 flows out of the port 84, and a portion of the purging fluid fed into the port 74 pressurizes and purges the internal passages in the valve 24a that are not connected to the ports 72, 82, or 70. These passages are purged through the ports 76 and 80, which are coupled to the bleed lines 26a (see Fig. 1). Modifications and additions can be made to the valve arrangement shown in Figs. 3a and 3b to adapt the system for long idle periods, evaporative ink, or infrequent ink changes. For example, the ports 76, 78, and 80 may be fitted with solenoid valves or other automated valves, and purging can be done at intervals. Port 70 may be fitted with a one-way valve only allowing passage of ink into valve 24a. Passage 71 may be eliminated and the openings of internal ports 73 and 79 sized to connect only at

the level of passage 81 if ink from port 70 is to be purged through the print head or through other ports downstream from port 84.

(026) Fig. 4 illustrates the valves 24a, 24b, and 24n implemented in a print apparatus. In Fig. 4, the color associated with the pump 22b is the selected printing color. To print using the color associated with the pump 22b, the valve 24b is arranged in the feed position (see Fig. 3b). The remaining valves in the apparatus are arranged in the bleed/prime position (see Fig. 3a). In this arrangement, when custom color ink is pumped by the selected pump 22b, the ink is directed by the valve 24b to the print head 12. Any flow from the unselected color pumps 22a, 22n and from the purging fluid pump 23 is directed to one or more of the bleed lines 26a, 26b, 26n. The flow of the ink and purging fluid is illustrated in part by arrows drawn through the valves 24a, 24b, and 24n. (Arrows are omitted from other potential fluid paths to enhance readability.) The line or tube connecting the ports 72a, 72b, 72n and 82a, 82b, 82n is the main ink line and can contain either ink, purge fluid, or a mixture of ink and purge fluid in normal operation. The line or tube connecting the ports 74a, 74b, 74n and 84a, 84b, 84n is an auxilliary line that contains purge fluid in normal operation.

(027) The color print apparatus operates as follows, with steps that may be taken under the direction of the controller 50:

(028) To purge custom colors, the feed valves are set to bleed/prime, the custom colors chambers are pumped at bleed pressure or bleed speed (low speed), and purging fluid is run through the print head until the output is clear.

(029) To make a new custom color, controlled amounts of primary color ink are provided to one of the custom color chambers and are mixed or allowed to mix.

(030) To start printing the new color from a custom color chamber (e.g., the chamber 20b), the color is primed, the associated feed valve 24b is set to feed, and the ink is pumped at purging speed through the print head. When the print head is loaded with the new color, printing is started. All other valves (24a and

24n) are set to bleed/prime. The valve 24n will pass fluid sent through the upstream valves to print head 12. Passages in valve 24n that are not connected to print head 12 are purged to the bleed lines 26n or pass ink from deselected color pump 22n to the bleed lines 26n. The purging fluid is fed at bleed pressure or bleed speed. Passages in valves that are set to feed or are set to bleed/prime are filled with either purge fluid, ink, or a mixture of purge fluid and ink. The passages in valves 26a, 26b, and 26n are always filled with fluid so that changing valve settings does not introduce air bubbles into the ink lines. In such manner, the feed valves 24 are operative to alternatively direct purging fluid from the purging fluid source 21/23 or ink from the custom color chamber 20 to the print head 12 without generating bubbles in the feed valve.

(031) To use a premixed color, one of the custom color chambers (such as chamber 20a) is removed and the feed tube 56 is cleaned as necessary, possibly during removal by the wiper 58 or a sponge or squeegie attached to the chamber. While the chamber 20a is removed, pumping from that chamber is disabled. The premixed color chamber with the desired color is installed and the new color is primed. This can be done during a printing operation.

(032) The controller 50 and supporting software are implemented to control the various functions described herein. Such implementation is well within ordinary skill in the relevant art. It should be understood that the programs, processes, methods and apparatus described herein are not related or limited to any particular type of computer or network apparatus (hardware or software), unless indicated otherwise. Various types of general purpose or specialized computer apparatus may be used with or perform operations in accordance with the teachings described herein. The control implementation may be expressed in software, hardware, and/or firmware.

(033) Although the invention has been described and illustrated with reference to specific illustrative embodiments thereof, it is not intended that the invention be limited to those illustrative embodiments. Those skilled in the art will recognize

that variations and modifications can be made without departing from the true scope and spirit of the invention as defined by the claims that follow. It is therefore intended to include within the invention all such variations and modifications as fall within the scope of the appended claims and equivalents thereof. The claims should not be read as limited to the described order or elements unless stated to that effect. In addition, use of the term "means" in any claim is intended to invoke 35 U.S.C. §112, paragraph 6, and any claim without the word "means" is not so intended.